

Introduction to OpenGL

**CSCI 4229/5229
Computer Graphics
Fall 2024**

History of Graphics Libraries

- PLOT-10: Tektronix 4010 graphics
- PLOT88: PC graphics
- DISSPLA: NCAR graphics
- GINO: Portable graphics
- DIGLIB: LLNL device-independent, open source
- GKS: Graphics Kernel System (2D vector)
- PHIGS: 3D Interactive Graphics
- OpenGL & DirectX

The rise of OpenGL

- Originated as SGI IrisGL
- Vendor-neutral OpenGL controlled by ARB
- Hides the details of hardware
 - Software emulation when necessary
 - Hardware acceleration when possible
- Supports 2D to advanced 3D graphics
- Portable to most hardware and OS with WGL, AGL and GLX
- Hardware range from phones to Big Iron

Focus of OpenGL

- OpenGL 1 (1992)
 - Hardware abstraction
- OpenGL 2 (2004)
 - Add Shaders (Programming the GPU)
- OpenGL 3 (2008)
 - Focus on shaders and new hardware
 - Deprecates many features
- OpenGL 4 (2010)
 - Core & Compatibility Profiles
 - Merge desktop and embedded versions

Gaming and Graphics

- Text based/ASCII graphics (Pong, PacMan)
- 2D monochrome line graphics (Astroids)
- 2D images & sprites (Mario)
- 3D graphics
 - Flight Simulators (2D -> 3D)
 - First Person Shooters
 - Multi-player games
- Games push the envelope
 - Realism
 - Speed

OpenGL by Example

- Learn OpenGL by reading
- nehe.gamedev.net
- lighthouse3d.com
 - Excellent free tutorials
- OpenGL: A Primer (3ed) by Edward Angel
 - Short and sweet
- OpenGL Programming Guide (Vermillion Book)
 - Free older editions as PDF
- OpenGL Superbible
 - Theory and Applications

What is OpenGL?

- Sometimes called a library, actually an Application Programming Interface (API)
- Specification is controlled by Khronos
- Multiple implementations by different vendors
 - Mesa & FreeGLUT free implementations
- OpenGL just does real time graphics
 - Need GLX/WGL/AGL for windowing and input
 - Limited font support (in GLUT)
 - No sound, printing, etc. support

OpenGL Versions

- 1.0 Initial release (1992)
- 1.1 Major upgrade (1997)
 - Latest version on some Windows system
- 1.2 Improves textures (1998)
- 1.3-1.5 Incremental improvements (2001-2003)
- 2.0 Relaxes restrictions, adds shader (2004)
- 2.1-2.3 Incremental improvement (2006-7)
- 3.0 Support advanced hardware features (2008)
- 3.1-3.3 Improved shaders (2009)
- 4.0 Merge desktop and devices (2010)
- 4.1-4.x Additional shaders

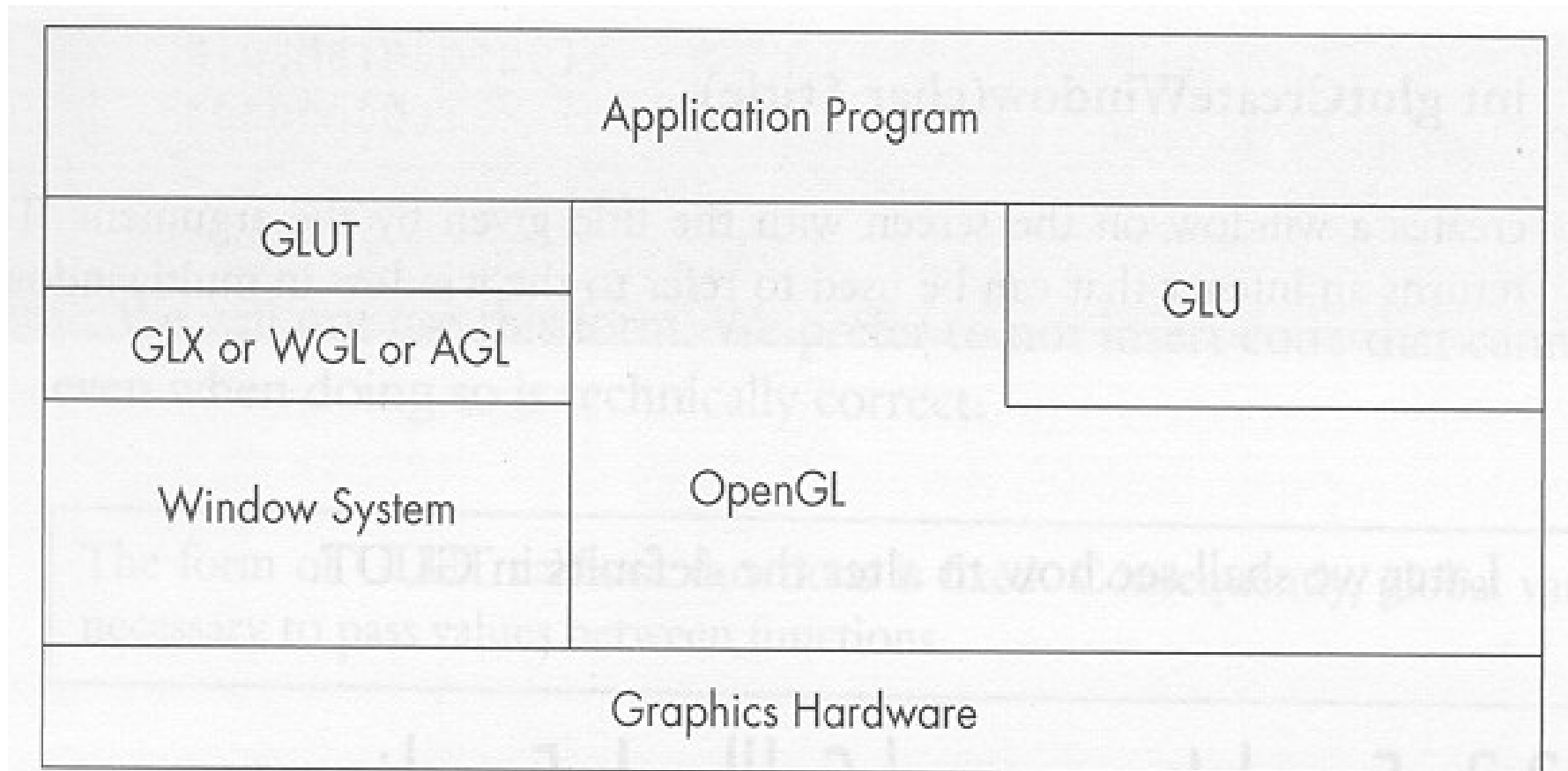
OpenGL Deprecation

- I will mostly use OpenGL 2.0
 - Feature rich, flat learning curve
 - I will use GL3 or GL4 only as needed
- OpenGL Core Profile concentrates on rendering
 - Improved execution time performance
- User must provide deprecated functionality
 - Steepens the learning curve
 - Deprecated features in Compatibility Profile
 - Increases reliance on third party libraries
 - Adds development time until tools mature

OpenGL APIs

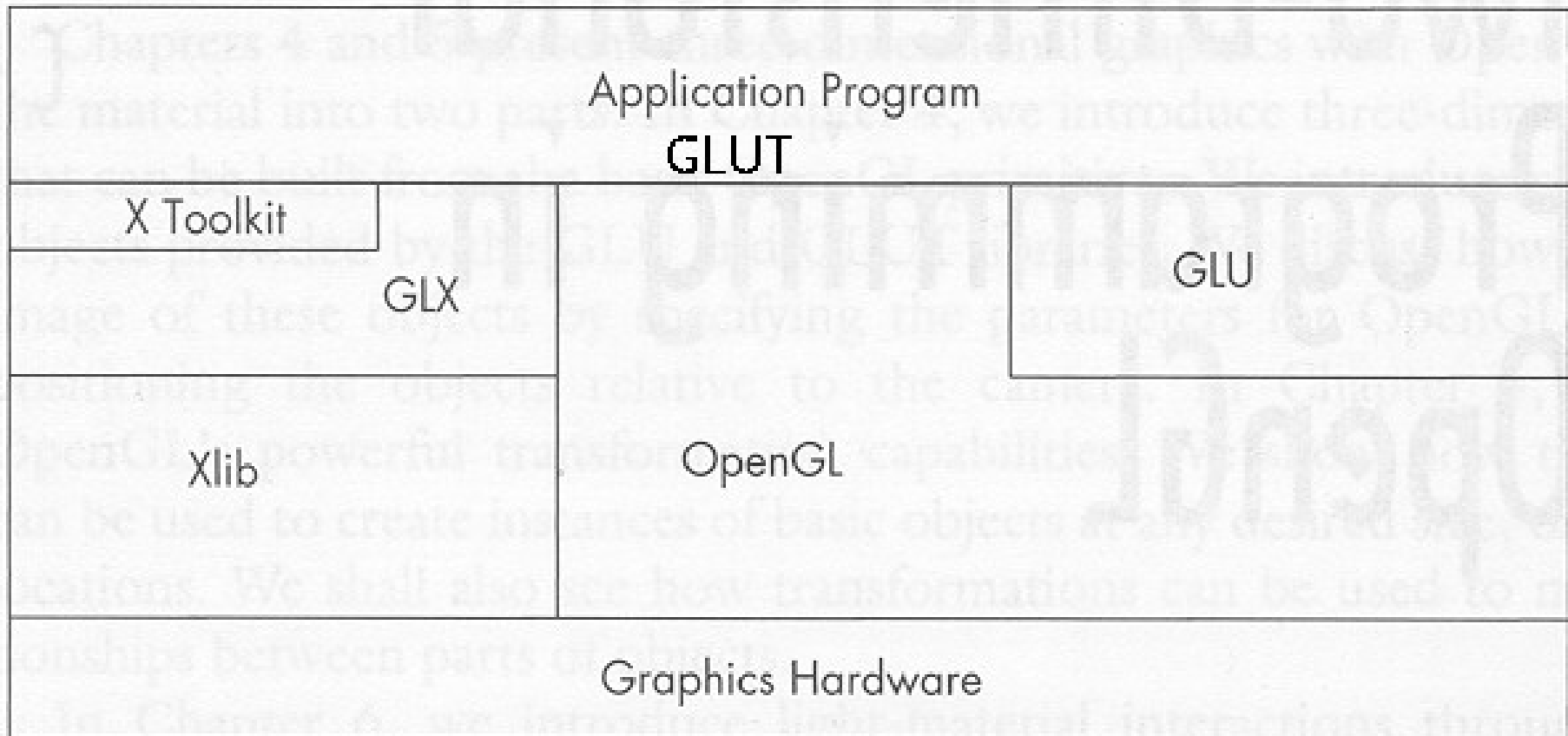
- Languages
 - C, C++, C#
 - FORTRAN
 - Java
 - Perl
 - Python
 - Ada
- Packages
 - Qt (QOpenGLWidget)
 - SDL, glfw, etc
 - Many others

OpenGL and Friends



From *OpenGL: A Primer*

OpenGL on X11



From *OpenGL: A Primer*

GLU: OpenGL Utility

- Higher Level and Convenience Functions
 - Projections
 - Creating texture maps
 - NURBS, quadrics, tessalation
 - Predefined objects (sphere, cylinder, teapot)
- Collections of calls for convenience
- Standard with all OpenGL implementations

GLUT: GL Utility Toolkit

- Provides access to OS and Window System
 - Open windows and setting size and capabilities
 - Register and triggers callbacks
 - Keyboard and mouse interaction
 - Elementary fonts
- Not part of OpenGL, but provides a portable abstraction of the OS
 - FreeGLUT
 - OpenGLUT
- Alternatives: SDL, Qt, glfw, ...

Header Files and Libraries

- Usually you only need
 - `#define GL_GLEXT_PROTOTYPES`
 - `#include <GL/glut.h>`
- Header file locations
 - `/usr/include/GL` on most systems
- Linking may only need
 - `-l glut -l GLU -l GL`
- Special cases
 - OS/X separates GL and GLUT
 - Windows differs depending on the compiler

OpenGL Naming Convention

- glSomethingNt()
 - *Something* is the name of the function
 - N is 2 or 3 or 4 for the dimension
 - t is for the the variable type
 - b GLbyte (signed char) 8 bit
 - s GLshort (signed short) 16 bit
 - i GLint (signed int) 32 bit
 - ub GLubyte (unsigned char) 8 bit
 - us GLushort (unsigned short) 16 bit
 - ui GLuint (unsigned int) 32 bit
 - f GLfloat (float) 32 bit
 - d GLdouble (double) 64 bit

OpenGL Naming Example

- Vertex
 - glVertex3i(0 , 0 , 1)
 - glVertex2d(27.34 , 88.12)
 - glVertex3dv(array)
- Few functions return a value
- Most functions created by name mangling
- Constants are GL_SOMETHING
- Variable types are GLsomething

GLUT and GLU Naming

- Functions
 - glutSomething
 - gluSomething
- Constants
 - GLUT_SOMETHING
 - GLU_SOMETHING
- You can always tell by the name which API supplies a function or constant
- Avoid things starting with glx, wgl & agl

GLUT: GL Utility Toolkit

- Supplies interface to OS
 - Windowing
 - Interaction
- Hello World in GLUT (well sorta)

```
int main(int argc, char* argv[ ])
{
    glutInit(&argc, argv);
    glutCreateWindow("Hello World");
    glutDisplayFunc(display);
    glutMainLoop();
}
```

Completing Hello World

- Draw a triangle

```
#include <GL/glut.h>
void display()
{
    glClear(GL_COLOR_BUFFER_BIT);
    glBegin(GL_POLYGON);
    glVertex2f(0.0,0.5);
    glVertex2f(0.5,-0.5);
    glVertex2f(-0.5,-0.5);
    glEnd();
    glFlush();
}
```

Compile, link and run

- `gcc -Wall -o ex1 ex1.c -lglut -lGL`
- Heavily relies on defaults
 - Window
 - Viewport
 - Projection
 - Color

